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The U.S. Coast Guard is in the process of recapitalizing its entire fleet of resources for offshore missions in one integrated long-term acquisition. The Integrated Deepwater System (IDS) Program will upgrade or replace the capabilities of existing assets in order to maximize operational effectiveness and minimize total ownership costs associated with the performance of all "Deepwater" missions. This system of systems acquisition is unique in its breadth among all government acquisitions in that it includes surface assets, aircraft, C4ISR (Command, Control, Communications, Computers, Intelligence, Surveillance and Reconnaissance) and logistics capabilities. Interoperability between all system assets will be a critical success factor of the Integrated Deepwater System performance. Success will be measured by the performance of the entire Deepwater System and total costs of operation and support. This paper will discuss how the program has focused on developing a framework for successfully ensuring interoperability as it applies to intra-Coast Guard and inter-agency operations. Among the methods discussed are: use of specifications, Government/Contractor relationships, design development, contracting vehicles, software tools and inter-agency agreements.

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The Integrated Deepwater System (IDS) – Ensuring Interoperability in the Acquisition of a Total System of Systems

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ABSTRACT

The U. S. Coast Guard is in the process of recapitalizing its entire fleet of resources for offshore missions in one integrated long-term acquisition. The Integrated Deepwater System (IDS) Program will upgrade or replace the capabilities of existing assets in order to maximize operational effectiveness and minimize total ownership costs associated with the performance of all "Deepwater" missions. This system-of-systems acquisition is unique among all government acquisitions due to its broad scope, which includes surface assets, aircraft, and C4ISR (Command, Control, Communications, Computers, Intelligence, Surveillance and Reconnaissance) and logistics capabilities. Interoperability between all system assets will be a critical success factor of Integrated Deepwater System performance. Success will be measured by the performance of the entire Deepwater system and the total ownership cost associated with it. This paper will discuss how the program has focused on developing a framework for successfully ensuring interoperability as it applies to intra-Coast Guard and inter-agency operations. Among the methods discussed are: use of specifications, Government/Contractor relationships, design development, contracting vehicles, software tools and inter-agency agreements.

INTRODUCTION

Background

The U. S. Coast Guard is in the midst of a readiness crisis due to capability and availability gaps with both our asset infrastructure and workforce. The Coast Guard cutters and aircraft that perform missions in the offshore environment are at, or beyond, their designed end of service life. Of the 39 largest "Navies" in the world, the U. S. Coast Guard is the 37th oldest in terms of average asset age. [1] Our support infrastructure is severely strained trying to maintain the readiness of these aging assets. Since 1993 the Coast Guard has experienced a steady decline in funding available for maintenance and upgrades. This has resulted in major cutters and aircraft being decommissioned due to poor or unsafe conditions. Three Island Class 110' patrol boats recently experienced life-threatening flooding while underway in normal conditions. Severe material deterioration and intensive operational requirements have created a dangerous condition for these thin-hulled patrol boats. Readiness is declining. By necessity, the Coast Guard has had to focus constrained resources on asset availability rather than on a long-term balanced approach combining availability and modernization. As VADM Joseph Dyer, Commander Naval Air Systems Command has aptly stated, "We've worked so long to do the best we can with what we have that there is

some risk that we have lost sight of what it really takes to do our business and to do it well, what it takes to sustain readiness and to recapitalize for tomorrow." [2]

Our workforce has exceptionally dedicated people who consistently demonstrate their commitment to the Coast Guard in spite of these readiness problems. However, the lack of funding that brought about these problems has also impacted our workforce since we have not had the funding necessary to prepare enough of our people to capitalize on new technology when it does come available. Recapitalizing such a broad and complex system in the midst of decline requires not only huge efforts, but also new strategies. The Coast Guard is now relying on the Integrated Deepwater System Program to recapitalize our assets and logistics systems while improving our operational effectiveness and interoperability. This integrated approach has to date received strong support from the Department of Transportation and the Bush administration. President Bush himself has recognized the Coast Guard's dilemma when he said the following, "We must make sure that our Coast Guard has got a modern fleet of vessels. We must make sure that port security is as strong as possible. We must make sure there's additional operating money available for the extended missions of the Coast Guard." [3]

Total System Design

The call for a total "supersystem" design came in a paper presented in 1996 [4]. In his paper Mr. Hockberger describes a "total-system approach" to optimize a system greater than the ship. The Integrated Deepwater System (IDS) Program is just such an approach in that the system to be acquired, and optimized, is much greater than any single asset that contributes to mission performance. Although this paper discusses a "system of systems" acquisition, the IDS program is much more than a large acquisition of many disconnected systems. It is the acquisition of one integrated system where every design decision contributes to the design optimization of the total supersystem. This systems approach recognizes that optimization of the system may force trade-off decisions that preclude optimization of the individual components, and in some cases may require suboptimization of subsystems.

"Deepwater" is the name given to the acquisition project which began in 1998 with the award of the Phase 1 contract for three industry teams to develop a concept design for an Integrated Deepwater System. The Phase 1 Request for Proposals (RFP) identified the IDS as "...the surface, air, and command, control, communications, computers, intelligence, surveillance and reconnaissance (C4ISR) assets and logistics required by the U. S. Coast Guard to perform its statutory mandated missions in the Deepwater environment." As stated within the Deepwater System Performance Specification (SPS), the IDS shall be capable of achieving operational effectiveness goals in the Coast Guard's 14 federally mandated offshore missions, which fall under the following 5 categories [5]:

Maritime Safety

- Search and Rescue (SAR) The ability for assets to search for and locate distressed mariners and recover them from positions of peril; provide medical advice, assistance, or evacuation; and when necessary, provide subjects safe transport to shore side locations.
- International Ice Patrol (IIP) Ice flow observation and dissemination of information whenever the presence of icebergs threatens shipping routes.

Maritime Security

- Drug Interdiction Surveillance/presence and interdiction in areas where the possibility of contraband smuggling exists.
- General Law Enforcement Proactive patrolling and a reactive response to intelligence information that may be received.
- Alien Migrant Interdiction Operations (AMIO) Proactive patrols and interdiction operations necessary to counter the normal flow of illegal migrants.

Protection of Natural Resources

- Maritime Pollution (MARPOL) Enforcement and Response Surveillance operations to detect maritime pollution in violation of MARPOL 73/78.
- Living Marine Resources Enforcement (LMR) To project a sustained presence throughout the U. S. Exclusive Economic Zone (EEZ) and along its boundary, as well as in international areas of interest to the U. S. in order to meet the objectives of the Coast Guard fisheries law enforcement program.

Maritime Mobility

- Lightering Zone Enforcement Surveillance of lightering zones, conducting boardings as necessary.
- Foreign Vessel Inspection Surveillance of operating areas and conducting at sea boardings.

National Defense

- General Defense Operations Performing surveillance, visiting, boarding, searching and seizing, and providing berthing and logistics support for additional personnel while ensuring limited unit defense.
- Maritime Intercept Operations (MIO) Surveillance of assigned areas of responsibility, detecting and intercepting all shipping, and dispatching trained boarding or inspection teams.
- Port Operations, Security and Defense (POSD) Surveillance of assigned areas of operations and dispatching appropriate assets to investigate any threat to security.
- Environmental Defense Operations Assisting in the mitigation of environmental exploitation designed to disrupt defense operations.
- Peacetime Military Engagement (PME) Conducting all military activities intended to shape the security environment in peacetime.

The Deepwater environment has been generally defined as the area beyond 50 nautical miles offshore but includes any area that requires extended on scene presence, long transit distance to reach the operating area, forward deployment of forces, or a combination of these factors. Not all Deepwater assets are unique to Deepwater missions. Some resources overlap with other non-Deepwater mission areas. For example, all 206 rotary and fixed-wing aircraft have been identified as Deepwater legacy assets even though they also perform missions such as Search and Rescue in the "Inland" and "Coastal" regions. Numerous elements of the support infrastructure share both Deepwater and Non-Deepwater responsibilities. The legacy Deepwater surface assets have been defined as the 91 cutters that are 110 feet in length and larger, excluding buoy tenders and icebreakers. An example, yet not the oldest, of our Deepwater Legacy cutters is 213' USCGC ACUSHNET (WMEC 167) (Fig. 1). This cutter was originally commissioned in 1943 as a U. S. Navy seagoing tug and was transferred to the Coast Guard in the late 1970s. She currently performs Living Marine Resources Enforcement and Search and Rescue missions out of Ketchikan, Alaska.

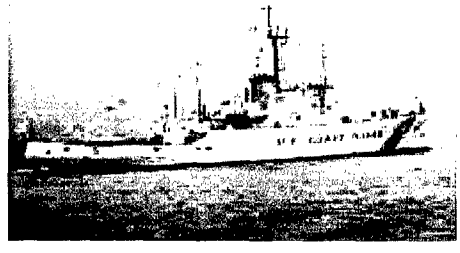

Figure 1 – USCGC Acushnet (WMEC 167)

Operations and support costs for current Deepwater assets encompass roughly 25% of the Coast Guard's approximately four billion dollar annual Operating Expense budget (1998).

As compared to a single asset class recapitalization project, the challenges of designing in interoperability become much more complex in system-of-systems project that encompasses many systems/subsystems and spans over decades. It is, however, anticipated that although more complex, the opportunities for cross-asset integration during design will

result in a much more interoperable Deepwater system.

Scoping Interoperability of the IDS

The IDS program is divided into four functional disciplines of Surface, Air, C4ISR (Command, Control, Communications, Computers, Intelligence, Surveillance, and Reconnaissance), and Integrated Logistics Support (ILS). In this paper we will discuss interoperability as it relates to both C4ISR and ILS because these two disciplines span across the entire program. By focusing on these specific functional disciplines for the design and implementation of the IDS, the Coast Guard is enabled to achieve maximum interoperability across surface and air assets of the IDS. These two functional areas are considered to be the overlapping system elements that will create a truly integrated Deepwater system (Fig. 2).

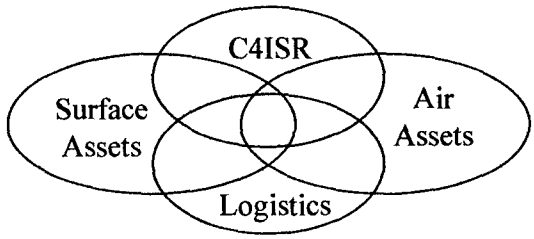

Figure 2 -Integrated System Elements

Three fundamental overlapping domains within which the Integrated Deepwater System will perform can be used to characterize the bounds of interoperability. These domains are presented for illustration purposes and do not change current IDS requirements. The degree to which interoperability requirements are set and achieved will be defined in detail after contract award by the sponsor, the IDS System Integrator and other agency stakeholders on a best value basis consistent with maximizing operational effectiveness and minimizing total ownership cost. (Fig. 3):

- the ability to effectively and efficiently be interoperable, execute and sustain missions with other forces such as DoD, NATO, and Law Enforcement agencies (Zone 1);
- the ability to effectively and efficiently be interoperable, execute and sustain missions within the pool of both current and new Integrated Deepwater System assets (e.g. surface, air, C4I, & logistics) (Zone 2); and
- the ability to effectively and efficiently be interoperable with non-Deepwater assets of the Coast Guard in terms of operability and supportability (Zone 3 below)

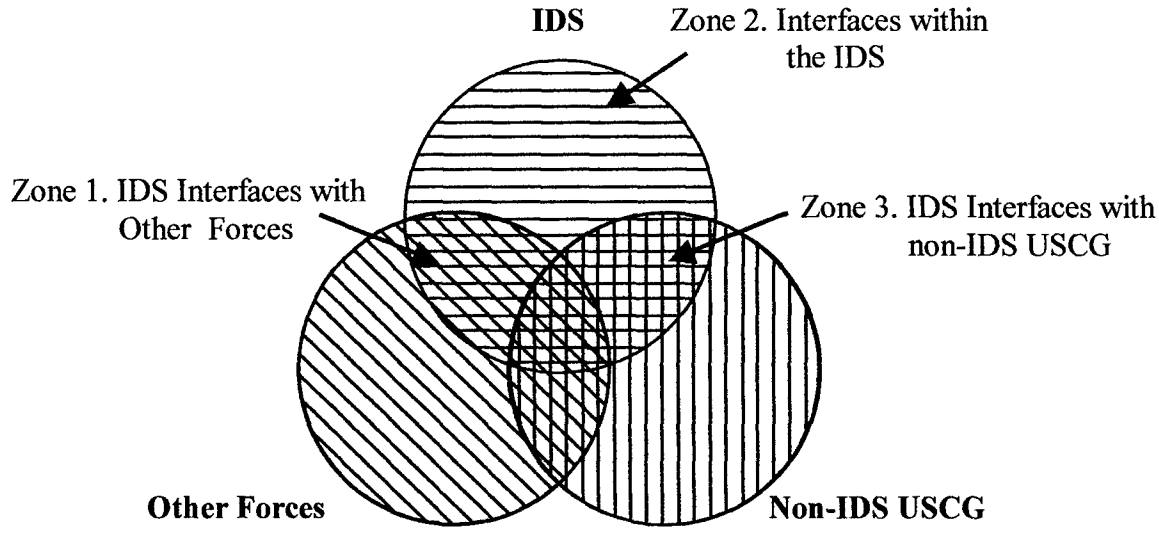

Figure 3 – Domains of Deepwater Interoperability

Zone 1 - Interoperability with "Other Forces"
The Joint Chiefs of Staff Instruction, CJCSI 6212.01B, "Interoperability and Supportability of National Security Systems, and Information Technology Systems" states that for the purposes of interoperability and supportability:

> "... all National Security Systems (NSS) and information technology systems (ITS) developed for use by US forces are for joint, combined, and coalition use. Interoperability and supportability of NSS and ITS requirements will be determined during the requirements validation process and will be updated as necessary throughout the acquisition period, deployment, and operational life of a system." [6]

As previously shown, five of the fourteen Deepwater mission capabilities for USCG assets contribute directly to national defense. Interoperability between the IDS and DoD/NATO forces will be the enabler for an integrated approach to executing these missions.

The requirements validation process for the IDS was conducted through the Interagency Task Force on Coast Guard Roles and Missions. In their final report the Task Force concluded:

> "In view of extremely capable U. S. military power, there is an increasing likelihood that a potential adversary may use asymmetric means to attack the United States. The Coast Guard has a role to facilitate and coordinate the integrated national response at the Nation's maritime gateway. ... Given the Coast Guard's existing capital infrastructure, its organizational competence, its legal authorities, and its substantial linkages to civilian response and law enforcement agencies, the Coast Guard will have an important role and likely several missions (both prevention and response) in the national strategy developed to deal with asymmetric threats. These missions are consistent with, draw effectiveness from, and contribute synergies to the Coast Guard's other safety, law enforcement, mobility, and national defense missions." [7]

In stating the recommendations for the USCG National Defense mission, the Task Force was clear in emphasizing the need for interoperability. The following are three recommendations specific to the USCG mission for National Defense:

- "Coast Guard cutters and personnel continue to receive appropriate Navy Training on a regular basis to ensure they are fully prepared to integrate into naval operations when needed.
- That Coast Guard cutters and aircraft maintain good interoperability with Navy and other DoD units, and that cutters remain equipped with, or be able to embark enough self-defense capability to enable them to operate in a low threat environment. Future Coast Guard cutters and aircraft should maintain the appropriate level of interoperability with Department of Defense systems and use common DoD systems where cost effective and mission efficient.
- To ensure the Coast Guard cutters of the future will be able to fulfill naval missions as assigned, the cutters must meet the well documented law enforcement requirements for good speed, endurance, sea-keeping, weapons, sensors and command and control interoperability with Department of Defense systems. In addition, the cutters must be equipped with, or be able to quickly embark, defensive systems as required in the System Performance Specification."

This report comprises part of the foundation for the development of Deepwater, and establishes the necessity for linkages and an "appropriate level of interoperability." Further, the recommendations characterize how the Coast Guard should fulfill its role in the spectrum of

capabilities for a Navy/Coast Guard "National Fleet" as detailed in a 1998 joint Navy/Coast Guard Policy Statement. [8] In this policy statement ADM Jay Johnson, Chief of Naval Operations, and ADM James Loy, Commandant USCG, "...commit to shared purpose and common effort focused on tailored operational integration of our multi-mission platforms, meeting the entire spectrum of America's twenty-first century maritime needs." Such reports and agreements have directed the IDS/DoD interoperability requirements development thus far in the program.

Besides the national defense missions requiring interface with NATO and DoD, the Coast Guard must have effective interoperability with other government agencies in the performance of its general law enforcement missions. In completing these missions the Coast Guard frequently works with agencies such as U. S. Customs Service, Immigration and Naturalization Service (INS), the Drug Enforcement Administration (DEA), and perhaps even local law enforcement agencies. With the heightened importance of Homeland Security, the IDS will need increasingly effective communications and shared intelligence in this domain to maximize its contribution to this mission.

Specific to logistics requirements within this area of Zone 1, our interoperability with the U.S. Navy regarding support, shared resources and commonality is a force multiplier in the initiatives of National Fleet. Further, there are benefits to the Navy potentially adapting the IDS National Security Cutter to the recently emerging Littoral Combat Ship (LCS).

Zone 2 - Interoperability within the IDS

The Integrated Deepwater System includes both legacy assets and those to be developed and produced over the next several decades. The period of phasing out legacy and phasing in new assets and capabilities will present an enormous challenge to optimal interoperability. However, the systems engineering approach to consistently maximize operational effectiveness predisposes the Coast Guard to an integrated approach where stove-piped capabilities should be minimized within the boundaries of the system. The integrated systems concept of the Integrated Deepwater System and disciplined systems engineering approach employed by the Deepwater Program, with one contractor serving as System Integrator, will provide an optimal framework for establishing interoperable capabilities and functions that are shared, compatible and supportable for sustained system performance. The initial requirements for the IDS were documented in the Deepwater Mission Needs Statement. Within this document it is stated,

> "It is critical that the Deepwater System be viewed in its totality ... ensure asset compatibility and interoperability, and provide the most affordable solution for the taxpayer." [9]

Additionally, the ease and speed with which new functions and capabilities can be implemented over the coming years of rapid technological advancement require interoperability through the operational, functional and support levels. As with other Armed Forces, the Coast Guard must engage in technology refreshment and be willing to explore and implement disruptive technologies to remain a relevant and effective naval service.

Zone 3 - Interoperability with Non-Deepwater Assets/Systems

The third domain of interoperability described is the interoperability between Coast Guard IDS and non-IDS assets and systems. Most operations, support and information technology functions are shared between the current Deepwater Coast Guard and those assets and systems that have not been included in the scope of the Deepwater acquisition program (e.g. buoy tenders, ice-breakers, coastal patrol boats and motor/surf boats). Integrated product development with Coast Guard stakeholders must result in coherent, detailed plans to avoid the negative effects of having Deepwater and non-Deepwater system incompatibility. Without the integrated approach, the risk of incompatibility is significant. The integrated approach to system development is intended to

minimize costly post-deployment fixes to interoperability problems.

The USCG missions for Deepwater, Coastal and Inland regions have some degree of overlap that will require operational and support interoperability. For example, the Coast Guard's new 87-foot Coastal Patrol Boat (CPB) may frequently operate with Deepwater assets (helicopters, fixed wing aircraft, National Security Cutter, etc.) in performing common coastal missions such as Maritime Pollution Enforcement and Response; Search and Rescue; Maritime Intercept Operations; and Port Operations, Security and Defense. For support interoperability the Coast Guard must be conscious of Deepwater and non-Deepwater logistics implications. A logistics support infrastructure for Deepwater that is incompatible and inoperable with non-Deepwater assets and systems will drive the Coast Guard to two systems. The overall costs and consequences of such an approach would have to be weighed prior to implementation. For this reason, ensuring interoperability within this intra-Coast Guard domain will be incumbent upon the Coast Guard and System Integrator working together within a partnership.

Besides the IDS program there are three other major C4I acquisition projects the Coast Guard is currently managing. These are the National Distress and Response System Modernization Project (NDRSMP), the Marine Information for Safety and Law Enforcement (MISLE) system, and the Ports And Waterways Safety Systems (PAWSS) project. Each has some overlap with Deepwater that necessitates a focus on ensuring adequate interoperability.

The objective of NDRSMP is to modernize and upgrade the communications system now used for the National Distress and Response System (NDRS). The National Distress and Response System provides the Coast Guard with a means to monitor the international VHF-FM distress frequency; coordinate search and rescue response operations; and communicate with commercial and recreational vessels. Other NDRS functions are to provide command and control (C2) for Coast Guard units (Active, Auxiliary, and Reserve) performing Maritime Safety, Maritime Security, National Defense, and Protection of Natural Resources missions. Additionally, the NDRS will provide communications between Coast Guard units (e.g., Air Stations, Marine Safety Offices, Stations, Port Security Units, cutters, boats, and aircraft), the Coast Guard's customers (e.g., recreational and commercial mariners), and partners such as federal, state, and local agencies.

MISLE is a Coast Guard major acquisition program intended to modernize the Maritime Safety and Law Enforcement information systems. These independent systems currently reside on Coast Guard hardware and software systems that are no longer supportable. MISLE is a robust web-based information system that will greatly facilitate a coordinated effort to improve Homeland Security capabilities. This is particularly relevant to the challenges our nation faces in ensuring security in our ports and waterways in the post September 11th environment.

The objective of PAWSS is to provide the equivalent of an air traffic control system for maritime traffic in U. S. ports and waterways through the use of off-the-shelf products that will automatically collect, process, and disseminate information on the movement and location of ships. The intended effect is to reduce the number of vessel accidents in ports and busy waterways by providing ships with up-to-the-minute information on vessel traffic conditions.

The Coast Guard has recognized that prior to implementing the NDRSMP, MISLE, PAWSS and IDS solutions it would be in the nation's best interest to ensure interoperability between these systems. Our Commandant has directed cross-program integration with the goal of ensuring maximum system interoperability. Following the tragic events of September 11th, he chartered a task force to review the operational requirements of these four projects to ensure that they contain provisions for internal interoperability, data sharing, and intercommunications in obtaining the Coast

Guard objectives for homeland security and maritime domain awareness.

From this charter,

> "The objective of the C4ISR Requirements Review Task Force is to review the operational requirements of the Coast Guard's various C4ISR programs and projects, and recommend adjustments to resources, schedules, policies or priorities needed to ensure connectivity with existing and planned systems, and implement interoperable and effective tools for prosecuting the Coast Guard's homeland security mission and enhancing our Maritime Domain Awareness (MDA) capabilities."[10]

Regarding the logistics implications of Zone 3 interoperability, Systems Logistics 21 (SL21) is a Coast Guard strategic initiative to allow the Coast Guard Logistics System to keep pace with the rapidly changing world of logistics. This plan calls for proactive evolutionary change based upon careful and systematic analysis of Coast Guard logistics processes (or activities) with the stated objective to improve effectiveness and efficiency. As the Coast Guard strives to enact this enterprise-wide logistics doctrine it must work with the IDS System Integrator to ensure commonality across systems and lowest possible total ownership cost.

The degree to which the Coast Guard ensures interoperability within and across all boundaries of these three domains will be driven by considerations of feasibility, operational effectiveness, affordability, national mandate, and political realities. Through the Deepwater IDS contract the Coast Guard will be partnering with a System Integrator to identify interoperability trade-offs in implementing the necessary Coast Guard Deepwater capabilities.

The challenge the Coast Guard faces with recapitalizing assets and capabilities is expansive and complex. Achieving effective, affordable interoperability remains an ever-present part of this great challenge. The high-level requirements of the Deepwater System Performance Specifications coupled with the collaborative approach to system development with the Deepwater Contractor Consortia and other government agencies are necessary first steps in this pursuit.

ACQUISITION APPROACH AND CONTRACT REQUIREMENTS

The acquisition philosophy of the IDS Program is unique for any federal agency procurement. It is the first time the Government has attempted to recapitalize its capabilities for an entire spectrum of missions over an extended period of time. Implementation and transition of assets will be managed through partnering with Industry at both a strategic and working level. It is through this large integrated system approach that the Coast Guard aims to realize cost savings and achieve performance synergies. The contract requirement for a system level C4ISR architecture and system level Integrated Logistics Support Plan, among other requirements built into the Deepwater acquisition, will help to bring about the desired cost and operational effectiveness objectives of the program.

The Deepwater system-of-systems acquisition approach relies on one Prime Contractor to serve as a System Integrator. Through various contractual requirements and processes developed to date within the Deepwater program, this contractor is responsible for meeting, and to some degree defining, interoperability requirements across all assets and systems. The Deepwater Program has implemented several strategies and requirements that serve as a foundation to ensure interoperability goals are achieved. This includes the use of: system performance specifications, a unique contracting strategy, Integrated Product and Process Development, system-wide test and evaluation, and inter-agency agreements.

System Performance Specification

The requirements document for the Integrated Deepwater System is a set of performance

specifications known as the System Performance Specification (SPS). [11] This set of specifications broadly defines the system level performance requirements of the IDS. A significant exception is the inclusion of a specification for a "National Security Cutter" (NSC) to serve as a surface asset of the IDS. The requirements for this asset include the ability to perform national security missions in a low threat environment. A required capability of this NSC is to meet frigate-like IT-21 (Information Technology for the 21st Century) standards to support joint tactical war fighting.

The SPS specifically addresses interoperability requirements within the two areas of C4ISR and ILS.

C4ISR Interoperability

The SPS addresses the system requirement that, "The IDS shall properly safeguard and handle secure and non-secure information exchanges up to a level of security that ensures interoperability with U. S. and allied forces." The SPS also addresses the interoperability requirements for the NSC as follows, "The national security cutter shall maintain real-time, two-way voice and data communications interoperability and relay capability with joint and allied forces."

The Deepwater requirement for computer resource interoperability has been stated in the SPS as follows: "IDS assets shall provide the capability for future software and hardware upgrades (open architecture), with sufficient documentation developed and maintained for software configuration management and upgrades. Where applicable and appropriate, the IDS shall be compliant with the Defense Information Infrastructure Common Operating Environment (DII COE), the Coast Guard Common Operating Environment (CG COE), the National Information Infrastructure (NII), the Global Information Infrastructure (GII), and commercial and non-developmental systems."

ILS Interoperability

Never before in a Coast Guard acquisition has Integrated Logistics Support had such an early and focused role. The Coast Guard has identified the importance of logistics in ensuring operational effectiveness (and interoperability) through the inclusion of logistics as one of the four deepwater functional disciplines within the IDS.

The IDS SPS has performance requirements that address the following logistics elements: personnel, training/training systems, systems safety, human factors engineering, habitability, maintenance, reliability, equipment commonality, modularity, open systems, component/subsystem/system interfaces, computer resources support, facilities, supply support, support & test equipment, packaging/handling and transportation, technical data, and integration with legacy logistics systems.

An example of how logistics planning is a cornerstone of the IDS is the system level performance requirement for modularity requires that, "The IDS shall incorporate modularity to facilitate maintenance and replacement of components or assets for short-term and long-term maintenance planning, and system upgrades to minimize life-cycle cost." Further, the SPS requires an "open system" approach to development. The specification reads, "Components and subsystems of all assets shall be open to the extent where future upgrades, level of modularity, and level of servicing is optimized with respect to cost within the life-cycle of the item (component, subsystem, and assets)."

With the emphasis in government acquisitions to capitalize on commercial and proven technology, and to reduce total ownership costs, program risk and development time, the Deepwater Program has mandated the use of Commercial, Off-the-Shelf (COTS) equipment to the maximum extent practicable. The difficulties associated with compatibility and interoperability between commercial and military hardware and software have been realized in recent years. In all cases, the engineering of equipment, hardware, software and effective compatibility must be accomplished and demonstrated. As a performance-based contract predicated on a systems engineering approach and systems level

testing program, the employment of COTS will be intelligently approached. System, subsystem, and component interfaces, defined in the various framework architecture views, form the foundation for the systematic approach to effective implementation. Concurrently, the requirement for embedding open architecture and commonality in system development provides beneficial characteristics for an enduring, effective system.

In order to ensure intra-Coast Guard interoperability the IDS SPS includes an interface requirement between newly developed IDS assets and current assets. The extent to which they are interoperable will be predicated on system effectiveness and affordability.

Although these system performance specifications lack substantive detail, they have provided the correct basis at the "Integrated Deepwater System" level for program management and development while giving the prospective System Integrator the broadest possible trade space to optimize the system design. It reinforces life-cycle considerations in the development of the system by ensuring the contractor employs a systems engineering approach to the development and technological refreshment of the system over the decades ahead. As such, it has provided support for the government in managing the contract during the design development as it relates to how details are manifested in the design. RADM Kate Paige, USN (previous Chief Engineer, Assistant Secretary of the Navy for Research, Development and Acquisition) has recently endorsed such an approach in her advice for program management in the development of interoperable systems. [12]

Contracting Strategy

The Deepwater Program has embarked on a unique contracting strategy to acquire an Integrated Deepwater System – all with the goal of ensuring an interoperable, optimized system of systems. This is summarized herein with a brief description of the Industry teams and timeline, the integrated systems approach, the Deepwater functional disciplines, our intended partnership with a single System Integrator, the phased procurement approach and requirements for technology refreshment.

The Deepwater Industry Teams and Timeline

The Coast Guard has had the benefit of working for the past three years with some of the worlds leading experts in ship and aircraft design and C4ISR and ILS integration. In 1998, Phase I of the Deepwater Contract was awarded to three Industry consortia requiring each to independently develop a concept design of the Integrated Deepwater System based on the SPS. The three industry teams, led by SAIC, Lockheed Martin Naval Electronics & Surveillance Systems and Avondale Shipyard/Boeing continued work until September 2001 to complete a functional design of their respective Integrated Deepwater System concepts. The industry teams emphasized maximizing total system operational effectiveness and minimizing total ownership cost (TOC) over the life of the system. Proposals from each team have been received and are currently under evaluation for award to a single team in third quarter of fiscal year 2002 where further development and implementation will begin.

Integrated Systems Approach

The one-for-one capability replacement approach that has characterized the Coast Guard's capital asset management over the years has resulted in interoperability deficiencies. Only one of the two classes of rotary wing aircraft that operate offshore can land on the three deepwater helicopter capable cutter classes. Numerous communications deficiencies plague cross asset interoperability due to outdated equipment and incompatibility. As illuminated by RADM Phillip Balisle, USN, (Director, Surface Warfare Division, OPNAV) two systems independently developed under separate program management but intended to be interoperable can present cataclysmic difficulties. [13] The system-of-systems approach for Deepwater corrals all capabilities of the Coast Guard's 14 Deepwater missions under one program and one system development. The Phase 2 Request for Proposals (RFP) requires the contractor to

provide an overall IDS C4ISR architecture to prevent the interoperability deficiencies discussed above. In order to better ensure interoperability with other systems the Coast Guard recognized the need to adopt a common C4ISR architecture framework. Therefore, the Phase 1 Statement of Work and Phase 2 RFP required the contractors to define their C4ISR architecture in the standard format of DoD C4ISR Architecture Framework V2.0. The C4ISR Architecture Framework, Version 2 was established to facilitate architecture descriptions that are inter-related and interoperable with other organization's operational, systems, and technical architecture views. [14]

This departure from plugging the holes in the dike, done with dedication worthy of the highest praise by the Coast Guard for years, is now being addressed with the depth and scope the service and country deserve. Dr. Vitalij Garber (Director of Interoperability, Under Secretary of Defense; Acquisition, Technology and Logistics) notes that across DoD there has been an "inadequate" level of emphasis placed on the systems engineering approach in program development. [15] For the first time, the Coast Guard is including all Surface, Air, C4ISR and Logistics capabilities across the 14 Deepwater missions in one program. It is a difficult but necessary step in order to avoid the pitfalls of inefficient gaps and overlaps otherwise characteristic of piecemeal recapitalization efforts.

Deepwater Functional Disciplines

As previously stated, a view of the high-level system of systems has been a necessary part of the IDS development, and this high-level system has been decomposed into four functional disciplines for the purpose of engineering design. These are: Surface, Air, Logistics and C4ISR. During the Phase 1 Concept and Functional Design period the Government was organized accordingly with four Matrix Product Teams, which were comprised of representatives of various Coast Guard organizational elements and other non-Coast Guard personnel. Members from each team were also designated with "cross functional" duties to address integration of issues that were shared between functional matrix teams. Government Technical Assessment Teams (TAT) were developed in each of these functional areas. These teams met with each of their counterparts on the industry teams approximately once a week in face-to-face meetings in order to give the contractor and Coast Guard a venue for sharing information during design development. Heavy involvement from the Coast Guard's Systems (Engineering) Directorate, SPAWAR, NAVAIR, and various Naval Surface Warfare Centers was instrumental in aiding in the development of sound functional designs. Our success to date has validated the need for cross-organizational involvement at all levels of system development and implementation.

Partnership with a Single System Integrator

In the third quarter of fiscal year 2002, the Coast Guard will award a contract to a Prime Contractor to manage the System Integration aspects of the IDS development. The contractor and the Coast Guard will rely heavily on the Prime Contractor to manage the development of a large part of the Coast Guard's future infrastructure and inventory. Many challenges exist, some of which include: a limited annual acquisition budget, constrained annual operating expense caps for Deepwater assets, and the complex task of transitioning many assets and systems while maintaining a high level of operational performance. These challenges, combined with the difficulties associated with forming new partnerships with both the Coast Guard and sub-contractors, makes the System Integrator's role truly daunting. It is, therefore, out of necessity and practical sense that the Coast Guard brings into the fold the enormous capabilities the selected Prime Contractor possesses in a manner that facilitates the cross pollination of needs and information with consistent efficiency and minimum time. The Deepwater Project Office will move from Coast Guard Headquarters to the Contractor's System Integration Project Office upon award, and establish a business partnership and teaming arrangement. The IDS contract is structured with an initial five-year term with the System Integrator with options for additional 5-year segments. Many initial delivery orders for Surface, Air, and C4ISR assets have a Cost Plus

Award Fee type price structure to accommodate the design maturity level to date and the dynamics of initial system development. An award fee incentive was included in the RFP to reward superior System Integrator performance with continued work in implementing the IDS.

Phased Procurement Approach

The IDS RFP includes a System Integration and Management Statement of Work (SOW) and four Asset Statements of Objectives (SOO) (one for each of the functional disciplines mentioned above: ILS, C4ISR, Surface, and Air). The system integration task order is the contract with the System Integrator and it requires the overall management effort for IDS design and implementation. This overall management effort will result in the task and delivery orders necessary to design and implement the specific ILS, C4ISR, Surface and Air Assets. Task and delivery orders correspond with the phased procurement structure recommended by DoD Directive 5000.2R for major systems acquisitions. As demonstrated below (fig. 4), IDS SOWs will be issued in the following five procurement phases that correspond to the Integrated Master Schedule of the IDS and the respective level of design maturity for each asset:

(1) Concept and Technology Development;

(2) System Development and Demonstration;

(3) Production and Deployment;

(4) Operations and Support; and

(5) Disposal.

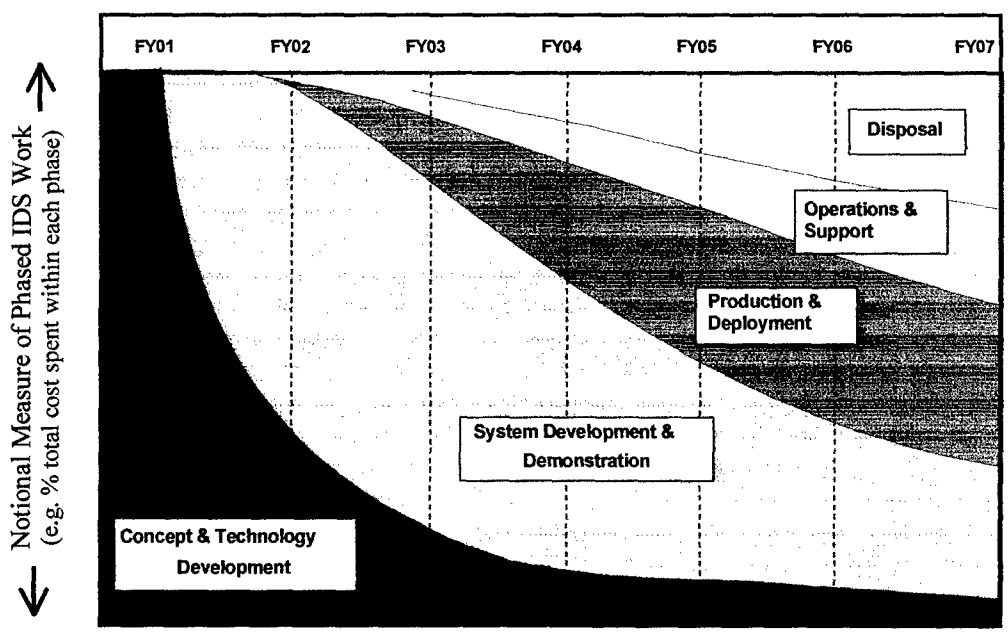

Figure 4 – Notional Phased Procurement Approach

This diagram illustrates that at any given time the various Deepwater activities may be in any phases of the life cycle acquisition process. These procurement phases will begin and end at various points and at different times based on the proposed implementation plan of the System Integrator. Figure 5 below shows a notional example of how a particular implementation plan may look within this phased procurement structure where multiple assets within each functional area are in different phases of development.

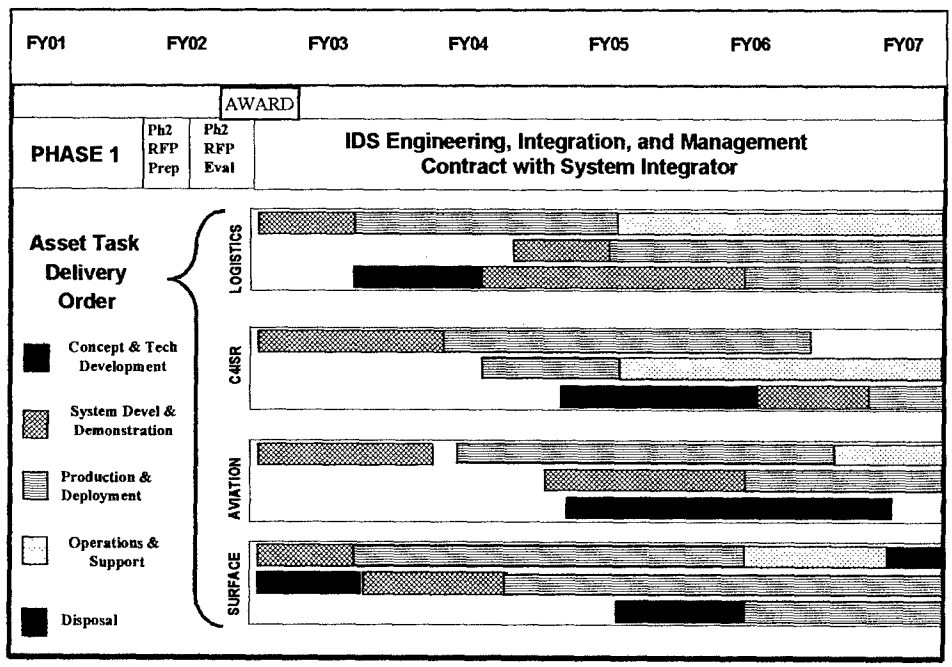

Figure 5 – Notional Phased Procurement Approach

The System Integrator will develop asset SOWs based on their implementation plan and the functional area Statements of Objectives (SOO) described in the Request for Proposals for the Phase II contract. The Statements of Objectives broadly describes the overarching objectives for each of the assets in the functional areas for each of the procurement phases. In addition, a minimum of requirements is described for each phase as necessary to provide clarity and to insert a level of structure to facilitate the appropriate Government insight. A great deal of emphasis remains on the systems engineering approach, demonstrated performance by the contractor and application of Integrated Product and Process Development (IPPD). As such, the specifications for contractor activity are more appropriately determined by the contractor with this approach. Figure 6 below demonstrates an example of how the SOO, Government input and Readiness Reviews will be used in developing the IDS.

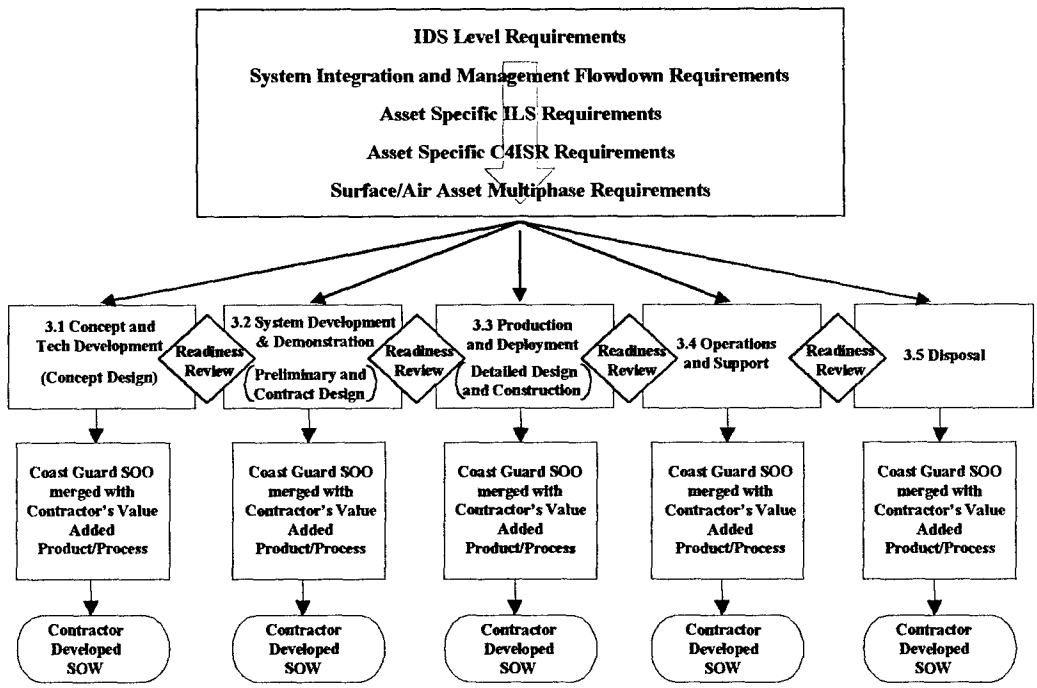

Figure 6 - Surface Asset Statement of Objectives (SOO) / Statement of Work (SOW) Development Flow

Technology Refreshment

One requirement of the System Integration and Management SOW is that the Contractor implement a technology refreshment program to ensure that delivered assets, subsystems, equipment, and software do not become technologically obsolete during the lifetime of the IDS. The IDS RFP [16] requires that continued technology suitability shall be assessed considering the following minimum criteria:

(a) Whether the product is no longer in production, or whether the product is expected to be phased out of production by the original equipment manufacturer;

(b) Whether the product is no longer commercially supported, or whether suppliers are intending to phase out commercial support;

(c) Whether the products' maintenance costs exceed replacement costs with updated technology/products;

(d) Whether changes in environmental regulations result in IDS system or subsystem non-compliance with international, national, state or local regulations;

(e) Whether Coast Guard Deepwater mission changes introduce the need for new or different capabilities;

(f) Whether baseline IDS technology proves to be ineffective;

(g) Whether significant performance gain (operational and/or support) can be realized due to updated or alternate applications of technology/product offerings.

It is anticipated that this IDS acquisition contracting strategy will contribute to ensuring maximum interoperability by encouraging flexibility, innovation and industry/government collaboration.

Integrated Product and Process Development

Integrated Product and Process Development (IPPD) is a contract requirement and includes formal partnering agreements, IPPD team training, and a web based Integrated Product Data Environment (IPDE) to serve as a data repository and design environment. Integrated Product Teams (IPT) are the primary basis of the government's organizational development with full anticipation that the government and industry counterpart teams will partner and unify efforts after award. The program management staffs from Government and Industry will collocate at a Systems Integration Program Office (SIPO) for managing program development.

A recognized element in forming high performance teams is to ensure the team members are well qualified and empowered to perform the necessary tasking. Given the broad scope, complex nature, and wide geographic dispersion of product development activities associated with the Deepwater acquisition program innovative approaches will be necessary to ensure full collaboration. To this end, the Deepwater program anticipates active involvement from various Coast Guard technical centers and Navy and DoD facilities as essential elements of effecting interoperability into the design and production of assets.

Test and Evaluation

The overarching objective of the IDS Program is to maximize operational effectiveness and minimize total ownership cost. In the Deepwater program, shipyards and aircraft manufacturing facilities may now be "sub-contractors" and the products represent single entities that will contribute to overall system performance. In the systems engineering approach the functions are naturally allocated to the assets. Concurrent with design development and as required by contract, a Test and Evaluation Master Plan template provided by the government will be used by the System Integrator, asset IPTs and Systems Engineering IPTs to create a Test and Evaluation system to ensure system level tests are conducted throughout development and beyond introduction of the asset into service.

For example, a "super asset" which may be a combination of two cutters and an aircraft will be tested for operational effectiveness in an initial operational capability test. Integral to the test will be demands that stress the interoperability within and external to the super asset based on prescribed capabilities in a variety of mission environments. Upon cursory consideration, the dimensions of this type of testing become evident since it requires participation and cooperation from many elements within and external to the Coast Guard. The IDS Program is currently developing agreements with the Department of Navy's Commander, Operational Test and Evaluation Force (COMOPTEVFOR) to facilitate and conduct such testing. The resources and capabilities that this body of expertise brings to bear are expected to provide substantive benefit, including a thorough exploration of the interoperability effectiveness.

Testing below the "super asset" level would occur, for example, prior to and upon delivery of a National Security Cutter. It is anticipated that the Navy's Board of Inspection and Survey (INSURV) will bring their expertise to acceptance trials. The C4ISR architecture, prescribed modular capabilities, and Operational Requirements Documents are among the body of performance requirements and contract documents that will drive the testing of interoperability effectiveness.

In both cases, the processes each of these groups employ will have to be adapted to the Deepwater contract and acquisition approach to minimize unanticipated impacts while capitalizing on the enormous talent and experience they provide.

Subsequent to Phase I development, the Request for Proposals for Phase II (award to a single prime contractor) includes the following requirement for system interoperability testing:

"The Contractor shall conduct Intra-Coast Guard and Inter-Government interoperability testing. The Contractor shall identify a test plan that shows how the C4ISR Asset interoperability performance objectives, compliance goals, standards and benchmarks to be employed will be tested. The results of these testing efforts shall address the following issues, but not necessarily be limited to:

a) Interoperability with other C4ISR systems and IDS assets

b) Interoperability with non-IDS Coast Guard assets (e.g. Vessel Traffic System, National Distress Response System, Coastal Patrol Boats, Buoy Tenders, Group Command Centers, etc.)

c) Interoperability with DoD assets; which encompasses System/Shipboard Operation, Verification, and Test (SOVT) – interoperability testing with surface assets, or Navy carrier battle group/amphibious ready group deploying platforms to include prime contractor interface with the Naval Sea Systems Command/Space and Naval Warfare Systems Center-Distributed Engineering Plant (DEP).

d) Interoperability with other Government agency assets (e.g. state, local, emergency response, disaster relief, law enforcement, etc.)."

An additional requirement within this section is for the Contractor to " further identify methods to ensure and measure interoperability between systems." A suggested tool for consideration is DoD's Levels of Information System Interoperability (LISI) Inspector Tool. During the Phase I Functional Design phase of the IDS the Coast Guard recognized the need for such a tool to assist in quantifying the level of interoperability of various IDS systems. For this reason the IDS program implemented the use of LISI to collect data to assess the interoperability of our existing systems.

Inter-Agency Agreements

The Coast Guard represents a small segment of capabilities that must be part of the national interoperability picture. Our involvement with other government agencies, especially DoD, necessitates a continuing collaboration at the strategic and deck plate level in order to achieve the level of desired interoperability. It is a strategic and practical imperative to ensure that interagency collaboration is established and maintained to achieve the desired end state. For example, Deepwater's extensive involvement with SPAWAR, NAVSEA and various Navy offices has proven crucial in the program's development thus far. For Deepwater, the Sponsor's representatives have been instrumental in continuing program development while representing the Coast Guard in establishing requirements with the Navy that will result in compatible solutions. Although the IDS Program and extended Coast Guard personnel will be partnering with industry in system development, our collaboration with DoD and other agencies remains an obvious and essential element for success. The necessary expertise to develop effective interoperability does not reside in one place, rather, the Coast Guard must predispose itself to cross-functional teamwork at all levels.

As previously mentioned, the Chief of Naval Operations and the Commandant of the Coast Guard have directed the Navy and Coast Guard to align their respective capabilities development to form a National Fleet. This document highlights the intent of each service's senior leadership to ensure joint interoperability:

"The National Fleet has two main attributes. First, the fleet is comprised of surface combatants and major cutters that are affordable, adaptable, interoperable, and with complementary capabilities. Second, whenever appropriate, the fleet is designed around common equipment and systems, and includes coordinated operational planning, training and logistics. The Navy's contribution will be highly capable multi-mission Navy surface combatants designed for the full spectrum of naval operations, from

> Peacetime Engagement through Major Theater War (MTW). The Coast Guard's contribution will be maritime security cutters, designed for peacetime and crisis-response Coast Guard missions, and filling the requirement for relatively small, general-purpose, shallow draft warships. All ships and aircraft of the National Fleet will be interoperable to provide force depth for peacetime missions, crisis response, and MTW tasks."

The events of September 11th and increased emphasis on both Homeland Defense and the Littoral Combat Ship under the evolutionary DD(X) program, highlight the pressing nature of our senior leadership's direction. The sponsor of the Deepwater Program, the Assistant Commandant for Operations, and his representatives have been engaged and integral to the development of the Deepwater Program from its inception. This same group of individuals also has represented the Coast Guard in recent years collaborating with the Navy on National Fleet initiatives and associated requirements development. Significant progress has been made and a mutually beneficial relationship has been formed between the IDS Sponsor's representatives and members of the Navy's counterpart offices. Much to the benefit of all concerned, the incorporation of the Deepwater Sponsor's representatives in the development of National Fleet initiatives has been a tremendous benefit in balancing the needs of the National Fleet and the interests of the Deepwater program and the Coast Guard. Interoperability requirements regarding support, communications, defense and strike capabilities have yet to be fully defined but an essential and appropriate foundation has been laid.

CONCLUSION

The Integrated Deepwater System Program is best characterized as a supersystem-level, performance-based, recapitalization enterprise whose success is predicated on a robust partnership between many elements of government and industry. The Deepwater capabilities recapitalization efforts are in the early stages and are progressing well. Several elements of the program strategy have been implemented to ensure the desired state of interoperability is achieved. The Coast Guard's Deepwater capabilities serve many needs internal and external to the Coast Guard's Deepwater realm including the non-Deepwater Coast Guard and other government agencies. The IDS Program is the largest acquisition the Coast Guard has ever endeavored and it is unique in its scope and strategy. It is an acquisition, however, and it must be affordable; not just by the constraints of funding, but by ensuring a rigorous and comprehensive systems engineering and integrated product and process development approach to achieve interoperability correctly "the first time" and as much as possible. This cannot be achieved without a truly integrated approach across all borders of government and industry.

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CDR Paul Roden is Deputy Chief for the USCG Headquarters Office of Systems Deepwater Integration (G-SDW). He graduated from the U. S. Coast Guard Academy in 1983 with a BSE in Marine Engineering, and then earned an MSE in Naval Architecture & Marine Engineering and an MSE in Mechanical Engineering from the University of Michigan in 1991. CDR Roden has had Naval Engineering tours aboard three classes of cutters, has served as 110' WPB and 210' WMEC type desk at the Seventh District Naval Engineering office in Miami, and has been an Assistant Professor of Naval Architecture and Marine Engineering at the U. S. Coast Guard Academy. CDR Roden is registered as a Professional Engineer in the state of Michigan.

CDR Doug Henke is the Project Manager for Surface Acquisitions of the Integrated Deepwater System Program Executive Office. He graduated from the U. S. Coast Guard Academy in 1985 with a degree in Naval Architecture and Marine Engineering. He has spent six years serving on various Coast Guard ships as a Deck Watch Office, Student Engineer and Chief Engineer. CDR Henke attended graduate school at MIT earning Masters Degrees in Naval Architecture and Marine Engineering as well as Mechanical Engineering in 1992. His previous assignment was at the U. S. Coast Guard Academy on staff with the Naval Architecture and Marine Engineering department where he taught various courses in naval architecture and ship design as well as numerous fundamental engineering courses. He was assigned to the Deepwater Project at Coast Guard Headquarters in the summer of 1999 and transitioned to the Assistant Project Manager for Surface position in October, 1999.

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The opinions expressed within this paper are those solely of the authors and are not intended to represent the opinions or policies of the IDS Program PEO, Assistant Commandant for Systems, U. S. Coast Guard, Department of Transportation or any other Government Agency. Nothing within this paper should be construed as being contrary to any IDS contract documents. For questions regarding any possible conflicts please contact the IDS Program Contracting Officer.